

## CLAIMS

What is claimed is:

1. An apparatus comprising:
  - a semiconductor substrate having a front side upon which an active device layer can be fabricated, and having a back side;
  - a diamond thermal layer coupled to the back side of the semiconductor substrate;
  - a back side component embedded in the diamond thermal layer; and
  - a via electrically connecting the back side component to the front side of the semiconductor substrate.
2. The apparatus of claim 1 wherein the back side component comprises a capacitor.
3. The apparatus of claim 1 wherein the back side component comprises an inductor.
4. The apparatus of claim 1 wherein the back side component comprises a resistor.
5. The apparatus of claim 1 wherein the back side component comprises an active component.
6. The apparatus of claim 1 further comprising:
  - the active device layer fabricated on the front side of the semiconductor substrate.
7. The apparatus of claim 1 further comprising:
  - a layer of thermal interface material overlying the diamond thermal layer; and
  - a thermal solution overlying the layer of thermal interface material.
8. The apparatus of claim 1 wherein the back side component comprises:
  - a plurality of layers of back side components.
9. The apparatus of claim 8 wherein the plurality of layers of back side components comprises:
  - a first plate anode and a first plate cathode of a first capacitor.
10. The apparatus of claim 9 wherein the plurality of layers of back side components further comprises:
  - a second plate anode and a second plate cathode of a second capacitor overlying the first capacitor.

- 1 11. An apparatus comprising:  
2 a semiconductor die having a front side and a back side;  
3 integrated circuit devices fabricated on the front side of the semiconductor die;  
4 a layer of material disposed on the back side of the semiconductor die, the material having a  
5 thermal conductivity greater than 150W/mK and an electrical resistivity greater than 1E9Ω-cm; and  
6 an electrical device disposed within the layer of material.
- 1 12. The apparatus of claim 11 wherein the electrical device is coupled to at least one of the  
2 integrated circuit devices by at least one via through the semiconductor die.
- 1 13. The apparatus of claim 12 wherein the electrical device comprises at least one of a capacitor,  
2 an inductor, and a resistor.
- 1 14. The apparatus of claim 13 further comprising:  
2 a thermal solution coupled to the layer of material.
- 1 15. The apparatus of claim 14 wherein the thermal solution comprises a heat sink coupled to the  
2 layer of material with a layer of thermal interface material.
- 1 16. The apparatus of claim 11 wherein the electrical device comprises two layers of electrical  
2 devices.
- 1 17. The apparatus of claim 11 wherein the electrical device comprises an electro-optical  
2 interconnect device.
- 1 18. The apparatus of claim 11 wherein the material comprises diamond.
- 1 19. The apparatus of claim 18 wherein the electrical device comprises a capacitor.
- 1 20. The apparatus of claim 11 wherein the material has a thermal conductivity greater than  
2 2000W/mK and an electrical resistivity greater than 1E15Ω-cm.
- 1 21. A method of manufacturing a semiconductor device, the method comprising:  
2 forming a first layer of high thermal conductivity material on a back side of a semiconductor  
3 substrate;

4 forming a hole through the first layer of high thermal conductivity material and the  
5 semiconductor substrate;  
6 forming a via in the hole;  
7 forming a first device overlying the layer of high thermal conductivity material on the back  
8 side of the semiconductor substrate and in electrical connection with the via;  
9 forming a second layer of high thermal conductivity material overlying the first device; and  
10 forming a second device on a front side of the semiconductor substrate and in electrical  
11 connection with the via.

1 22. The method of claim 21 further comprising:  
2 coupling a thermal solution to the second layer of high thermal conductivity material.

1 23. The method of claim 22 wherein the thermal solution comprises a heat sink and coupling the  
2 heat sink to the second layer of high thermal conductivity material comprises placing a layer of  
3 thermal interface material between the heat sink and the second layer of high thermal conductivity  
4 material.

1 24. The method of claim 21 wherein forming the first device comprises:  
2 forming an anode and a cathode, and the first device comprises a capacitor.

1 25. The method of claim 24 wherein forming the anode and the cathode comprises:  
2 fabricating the anode and the cathode to each have a plurality of fingers interlaced with  
3 fingers of the other.

1 26. The method of claim 24 wherein forming the anode and the cathode comprises:  
2 forming the anode as a plate and forming the cathode as a plate, one of the plates overlying  
3 the other; and  
4 forming a middle layer of high thermal conductivity material between the plates.

1 27. The method of claim 21 wherein the high thermal conductivity material comprises diamond.

1 28. The method of claim 27 wherein forming the layers of diamond comprises chemical vapor  
2 deposition.

1 29. The method of claim 21 further comprising, after forming the second layer of high thermal  
2 conductivity material and before forming the second device on the front side:

3 reducing a thickness of the semiconductor substrate.

1 30. The method of claim 21 wherein:

2 forming the hole comprises forming a plurality of holes;

3 forming the via comprises forming a plurality of vias in respective holes; and

4 forming the first device comprises forming a plurality of devices in electrical connection with  
5 respective subsets of the vias.

1 31. The method of claim 21 wherein forming the first device comprises:

2 fabricating a spiral inductor.

1 32. The method of claim 21 wherein forming the first device comprises:

2 fabricating a resistor.

1 33. The method of claim 21 wherein the high thermal conductivity material has a thermal  
2 conductivity greater than 150W/mK.

1 34. The method of claim 33 wherein the high thermal conductivity material has a thermal  
2 conductivity greater than 2000W/mK.

1 35. The method of claim 33 wherein the high thermal conductivity material has an electrical  
2 resistivity greater than 1E9Ω-cm.

1 36. The method of claim 35 wherein the high thermal conductivity material has a thermal  
2 conductivity greater than 2000W/mK.

1 37. The method of claim 36 wherein the high thermal conductivity material has an electrical  
2 resistivity greater than 1E15Ω-cm.

1 38. An article of manufacture comprising:

2 a machine-accessible medium including data that, when accessed by a machine, cause the  
3 machine to fabricate the apparatus of claim 1.

1 39. The article of manufacture of claim 38 wherein the machine-accessible medium further  
2 includes data that cause the machine to fabricate the apparatus of claim 2.

1 40. The article of manufacture of claim 38 wherein the machine-accessible medium comprises a  
2 recording medium.

1 41. The article of manufacture of claim 38 wherein the machine-accessible medium comprises a  
2 carrier wave.

1 42. An article of manufacture comprising:  
2 a machine-accessible medium including data that, when accessed by a machine, cause the  
3 machine to fabricate the apparatus of claim 11.

1 43. The article of manufacture of claim 42 wherein the machine-accessible medium further  
2 includes data that cause the machine to fabricate the apparatus of claim 19.

1 44. The article of manufacture of claim 43 wherein the machine-accessible medium comprises a  
2 recording medium.

1 45. The article of manufacture of claim 43 wherein the machine-accessible medium comprises a  
2 carrier wave.

1 46. An article of manufacture comprising:  
2 a machine-accessible medium including data that, when accessed by a semiconductor  
3 fabrication factory, cause the semiconductor fabrication factory to perform the method of claim 21.

1 47. The article of manufacture of claim 46 wherein the machine-accessible medium further  
2 includes data that cause the semiconductor fabrication factory to perform the method of claim 24.

1 48. The article of manufacture of claim 47 wherein the machine-accessible medium comprises a  
2 recording medium.

1 49. The article of manufacture of claim 47 wherein the machine-accessible medium comprises a  
2 carrier wave.